1999–2000 CATS ASSESSMENT
Open-Response Item Scoring Worksheet

Grade 7 – Science

The **academic expectations** addressed by the open-response item "Acid Rain" are:

2.1 Students understand scientific ways of thinking and working and use those methods to solve real-life problems.

2.2 Students identify, analyze, and use patterns such as cycles and trends to understand past and present events and predict possible future events.

The **core content** addressed by this item includes:

Properties and Changes of Properties in Matter

SC-M-1.1.2 The chemical properties of a substance cause it to react in predictable ways with other substances to form compounds with different characteristic properties. In chemical reactions, the total mass is conserved. Substances are often classified into groups if they react in similar ways.

Scientific Inquiry

- Students will communicate (e.g., write, graph) designs, procedures, observations, and results of scientific investigations.
- Students will use appropriate equipment, tools, techniques, technology, and mathematics to gather, analyze, and interpret scientific data.

ACID RAIN

Acid rain is a major problem in many parts of the United States. It can harm both plant and animal life and can cause changes to physical structures (natural or man-made). Rainwater is normally slightly acidic, but sometimes enough pollutants mix with the water in the sky to make the rainwater more acidic than normal.

a. Describe two tests you could perform to determine if the rainwater in your town is acidic.

b. Choose a plant, an animal, or a physical structure and explain what damage acid rain could do to it.

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Score	Description
4	The response is complete and shows an in-depth understanding of pH testing and the effects of acid rain. A clear description of two tests that would determine the acidity of the rain is presented. There is an accurate explanation of how acid rain could potentially damage a specific plant, animal, or physical structure.
3	The response shows an understanding of pH testing and the effects of acid rain. A description of at least one test that would determine the acidity of the rain is presented, but the response may not clearly describe how it would determine the acidity. There is a reasonable explanation of how acid rain could potentially damage a specific plant, animal, or physical structure. The response may lack detail or contain minor errors or misconceptions.
2	The response shows a limited understanding of pH testing and the effects of acid rain. There is a description of a test that would determine the acidity of rain and/or an explanation of how acid rain could potentially damage a specific plant, animal, or physical structure. The response may contain errors, misconceptions, or omissions.
1	The response is incomplete and shows a minimal understanding of pH testing and the effects of acid rain. There is an attempt to describe a test that would determine the acidity of rain, and/or explain the potential damage caused by acid rain. The response contains major errors, misconceptions, and omissions.
0	Response is totally incorrect or irrelevant.
Blank	No response.

Possible Student Response:

I would collect samples of rainwater from four different places around town and I would test them with pH paper to find out how acidic the water is. If the water is from 1-6 on the pH test it is acidic. If I didn't have pH paper I could use purple cabbage juice as an indicator for an acid. Acid rain could damage the leaves of a maple tree because it will burn them and make them yellow.

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Science Behind the Question:

Acidity can be measured using the pH scale. Acid rain is precipitation with below-normal pH, (usually 3-5 range) and is the result of industrial pollution and automobile exhaust emitted into the atmosphere. Many coal-burning power plants use high-sulfur coal because it is cheap and plentiful. Sulfur dioxide and nitrogen oxide found in these pollutants combine with water vapor to form acids. The accumulation of acid rain lowers the natural pH of lakes and ponds. How much a lake is affected can depend on the bedrock in the area and its ability to neutralize the acid. Rainwater normally has a pH of 5.6. Pure water has a pH of 7. Rainfall in some areas of the northeastern United States has a pH of 3.8, almost 100 times more acidic than the typical value for the rest of the country. To test the acidity, rainwater must be collected and tested for pH or acidity. Common methods are litmus paper, pH paper, universal indicator solution, and pH meters. Acid rain can also be detected as a result of its reaction with chemicals. For example, acid will cause marble or chalk dust to "fizz" as carbon dioxide is released by acid reacting with calcium carbonate. The same will happen with baking soda (sodium bicarbonate) or washing soda (sodium carbonate).

Acidity in rainfall affects physical structures by reacting or otherwise increasing solubility and speeding erosion. Acid rain can cause chemical damage to plant leaves, and to the skin and lung tissues of animals. By changing the soil chemistry, acid rain can affect plant growth, sometimes in negative or positive ways depending on the soil and the plant.

ANNOTATED STUDENT RESPONSE
Grade 7 Science

Sample 4-Point Response of Student Work

Student Response

Acid rain is a major problem in many parts of the United States. It can harm both plant and animal life and damage physical structures. In the next two paragraphs I will describe two tests that could be performed to determine if rainwater was acidic and what damage acid rain could do to a physical structure.

There are many ways to determine if rainwater in your town is acidic. Two ways to test if it is acidic or not is to test the water's pH or to mix the water with a known base like baking soda. In a "pH" test you collect a sample of rainwater and dip in a strip of pH paper. If the strip turned yellow, orange, or red the water would be considered acidic. In a baking soda test you would collect a sample of rainwater and mix some baking soda in the water. If the water bubbled and produced carbon dioxide gases then the chances of the water being acidic are high.

Acid rain can do damage to many things, both natural and man-made. On cars, acid rain is especially bad. Having a car exposed to acid rain continually can cause the paint to peel off. Only leaving the primer coat on. Even worse than not having a finish on your car is the metal damage acid rain can do.

Now I am sure you can understand how you can test for acid rain in your town, and also how acid rain can do damage to physical structures.

← Student clearly describes two tests that could determine the acidity of the rain (i.e., dipping a strip of pH paper into a rainwater sample and adding baking soda to a rainwater sample).

← Student accurately explains how acid rain could damage a physical structure (e.g., it "can cause the paint to peel off" a car).

Overall, the student shows a solid understanding of the concept that chemical properties of a substance cause it to react in predictable ways with other substances, as well as a strong ability to communicate procedures and observations of a scientific investigation. The student clearly describes two tests that could be performed to determine the acidity (pH) of rainwater and accurately explains how acid rain could damage a physical structure.

ANNOTATED STUDENT RESPONSE
Grade 7 Science

Sample 4-Point Response of Student Work

Student Response

Acid rain is a problem in the United States. I do not know if my town has acid rain. To find out I could perform two tests that would determine if my town has acid rain. The first test involves a cup of rainwater and a cup of cabbage juice. I would pour the rainwater in the cabbage juice. If the cabbage juice turns red the rainwater contains acid. If the juice stays its original purplish color it does not contain acid.

The other test I would perform involves a blue and a red litmus strip and a cup of rainwater. First, I would dip one end of the red strip in the rainwater. If it stays red that means it contains acid. If it turns blue that means it contains base. Next, I would dip the blue strip in the rainwater. If it stays blue it contains base. If it turns red it contains acid. If both strips turn red the water is acidic. If both stay the same the water is neutral.

Acid rain can harm or destroy physical structures. It can cause paint to wear off or it can even cause nails to rust. This just goes to show acidic rain is seriously strong.

← Student clearly describes one test that could determine the acidity of the rain (i.e., adding rainwater to cabbage juice).

← Student clearly describes a second test that could determine the acidity of the rain (i.e., dipping litmus strips into rainwater).

← Student accurately explains how acid rain could damage a physical structure (e.g., "cause nails to rust").

Overall, the student shows a solid understanding of the concept that chemical properties of a substance cause it to react in predictable ways with other substances, as well as a strong ability to communicate procedures and observations of a scientific investigation. The student clearly describes two tests that could be performed to determine the acidity (pH) of rainwater and accurately explains how acid rain could damage a physical structure.

ANNOTATED STUDENT RESPONSE
Grade 7 Science

Sample 3-Point Response of Student Work

Student Response

Two test I could perform is the litmus test. I could get the rain water from the sky and put it in a cup and if it came out red on a piece of paper then then it's acid rain but if it came out blue then it was bace. Or put a plant outside and one inside and give the one inside house water and the one outside give it the water from the sky and see which one live the longest.

B. Acid rain can damage a physical structure. For example a marble tumstone the acid rain can eat the structure away and until finally you can't see the writing on it.

← Student describes one test that could determine the acidity of rain (i.e., litmus paper test). Student attempts to describe a second test that could determine the acidity of rain (i.e., give an inside plant house water and an outside plant rainwater and "see which one live the longest"), but the test is incorrect.

← Student accurately explains how acid rain could damage a physical structure (i.e., "acid rain can eat [a tombstone] away…until finally you can't see the writing on it").

Overall, the student shows a good understanding of the concept that chemical properties of a substance cause it to react in predictable ways with other substances, as well as a good ability to communicate procedures and observations of a scientific investigation. The student clearly describes one test that could be performed to determine the acidity (pH) of rainwater; attempts to describe a second test, but the test is incorrect; and accurately explains how acid rain could damage a physical structure.

ANNOTATED STUDENT RESPONSE
Grade 7 Science

Sample 2-Point Response of Student Work

Student Response

One time when we were in school my teacher had these little strips and they tested the acidity of whatever you were testing that was a liquid. I would use those. I would get some liquids that I did not know their acidic level and I would test them. I am pretty familiar with the scale and here it is: 1-6 Acid, 7 water, 8-14 base. This would help me determine what kind of liquid it was. Like was it a acid, water, or a base.

If there would be an plant/animal I would choose it would be the venus fly trap. If I got some acid water and its level of acidity was 3 then it would probably have some major damage on it. It might hurt it badly or it might kill it. I remember when I spilled some acid on my hand and it burned me pretty bad. It feels a little worse than when you get some hot glue on yourself from a hot glue gun.

← Student provides a limited description of one test that would determine the acidity of a liquid (i.e., use "little strips" to test "liquids" and use a scale to determine the acidic level). Response does not include any direct reference to substances reacting with other substances or a direct reference to rainwater.

← Students explains the damage that acid rain could do to a plant (i.e., acid rain will damage, badly hurt, or kill a Venus flytrap).

Overall, the student shows some understanding of the concept that chemical properties of a substance cause it to react in predictable ways with other substances, as well as some ability to communicate procedures and observations of a scientific investigation. The student describes in vague terms one test that could be performed to determine the level of acidity (pH) of a liquid and explains the damage that acid rain could do to a plant.

ANNOTATED STUDENT RESPONSE
Grade 7 Science

Sample 1-Point Response of Student Work

Student Response

A. To test this water I would put two glasses out in the middle of my yard, letting the rain rain into them. Afterwards, I would take the two glasses of rain to keep. Nextly, I would get one empty glass and sit it out in the middle of my yard for the acid rain. After the acid rain, I would go and the new glass of acid rain and test it to the two glasses of rain water.

B. If I were a beautiful, full grown, colorful rose and acid rain began to fall I would most likely die. The reason for this is that the acid rain would burn me like a fire would, ruining all my functions to help me live.

← Student attempts to describe a test that would determine the acidity of the rain, but the test is incorrect.

← Student explains how acid rain could damage a plant (i.e., "the acid rain would burn [the plant] like a fire would"). Although the analogy to fire is exaggerated, the concept of acid burning is correct.

Overall, the student shows a minimal understanding of the concept that chemical properties of a substance cause it to react in predictable ways with other substances, as well as minimal ability to communicate procedures and observations of a scientific investigation. The student attempts to describe one test to determine the acidity (pH) of rainwater, but the test is incorrect; the student correctly explains that acid rain could burn a plant.

INSTRUCTIONAL STRATEGIES
Grade 7 Science

The open-response item **"Acid Rain"** was designed to address students' (1) understanding of properties and changes of properties in matter, and (2) ability to understand scientific ways of thinking and working and to use those methods to solve real-life problems. The instructional strategies below present ideas for helping students explore and master these concepts and skills.

Discuss the following concepts:

- A substance has characteristic properties.
- The chemical properties of a substance cause it to react in predictable ways with other substances to form compounds with different characteristic properties.
- Substances are often classified into groups if they react in similar ways.
- Appropriate equipment, tools, techniques, and mathematics are used to gather, analyze, and interpret scientific data.
- Evidence, logic, and scientific knowledge are used to develop scientific explanations.
- A process is used to design and conduct scientific investigations.
- Chemical reactions happen all around us.
- An individual's roles and responsibilities in local issues such as changes in the population, in the use and availability of resources, and in the environment.

Provide opportunities for students to work individually, in pairs, in small groups, and/or as a class to complete (with teacher guidance and support) any or all of the following activities:

- Investigate the differences between chemical reactions and physical changes. Create a school science Web site where the differences are explained and examples are given.
- Investigate the properties of acids and bases found in common household products or foods. Recognize how the pH scale is used to classify substances. Use various indicators such as litmus paper or cabbage juice to determine pH. Create charts or spreadsheets to organize data. Write articles for newspapers explaining how to identify acids and bases.
- Visit a pond or stream ecosystem and measure the pH and other physical parameters of the water over an extended period. Survey aquatic flora and fauna in the stream and/or pond. Investigate the tolerance limits of aquatic species to different pH levels. Explore how water quality impacts people's decisions to live in different areas. Create a documentary for community groups showing the water quality of the area.
- Invite guest speakers to discuss the impact of acid rain on local fish and wildlife. Write articles for school newspapers summarizing the discussion.

- Investigate sources of acid rain. Create maps that show how acid rain travels across the country. E-mail students from other parts of the country to determine how acid rain impacts communities.
- Investigate how acids and bases affect different Earth materials including rocks, minerals, soil, clay, and sand. Grow different types of seeds in soils with different pHs. Research qualities (e.g., flavor, texture) of crops grown in different soil types. Create brochures for nurseries explaining which seeds germinate well in acidic soils and which germinate well in basic soils.
- Research the long- and short-term effects of acid rain. Investigate ways to reduce acid rain. Contact city, county, or state officials to discuss local problems and develop solutions. Produce PowerPoint presentations for community groups.
- Debate the use of low-cost, high-sulfur coal versus high-cost, low-sulfur coal.